Simulation and analysis on different Mobile Wireless Ad Hoc Networks (MANET) routing protocols

Final Project Report

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Abstract

Mobile ad hoc network (MANET) is decentralized wireless network without a pre-existing infrastructure. MANET routing protocols should adjust to changes in the network topology and maintain routing information, so that data can be forwarded to their destinations. In this project, it describes the simulation and performance comparison of different routing protocols which are Dynamic Source Routing (DSR), Ad Hoc On-demand Distance Vector (AODV) and Temporally Ordered Routing Algorithm (TORA) protocol. Using Riverbed Modeler, different scenarios such as varying number of nodes, transmission power, source data rate and physical area can be analyzed by performance metrics such as end-to-end throughput.

Keywords: MANET; AODV; DSR; TORA

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List of Acronyms

MANET	Mobile Wireless Ad Hoc Networks
DSR	Dynamic Source Routing
AODV	Ad hoc On-Demand Distance Vector
TORA	Medium Access Control
DSDV	Destination-Sequenced Distance-Vector Routing
OLSR	Optimized Link State Routing Protocol
ZRP	Zone Routing Protocol
ZHLS	Zone-Based Hierarchical Link State
RREQ	Route Request
RREP	Route Reply
DAG	Directed Acyclic Graph

Chapter 1.

Introduction

1.1. Motivation

Firstly, the Mobile Ad-hoc Network is a collection of wireless nodes, mobile in nature and is capable of routing packets among themselves in situations where there is no network infrastructure available or using of any centralized administration is impossible. In MANET, every node not only plays the role of host but also the router, relaying the traffic by other nodes. The topology in Mobile Ad-hoc Network is dynamic because nodes may not be fixed or equally. Hence routing protocols in MANET are needed to support the proper functionality of the network. Moreover, routing protocols are designed to be complicated due to the interaction of three network issues such as contention, congestion and node connectivity [1].

Although each routing protocol has their own advantages based on their individual performances in the network. This paper provides a comparative study through simulation of three routing protocols (DSR, AODV, and TORA) for mobile ad-hoc networks using OPNET modeler. By setting constant values of parameters such as simulation time and traffic type, the objective of this paper is to evaluate the performances of three routing protocols for four different scenarios including varying number of nodes, transmission power, source data rate and physical area [12]. The performances had been analysed based on end-to-end throughput.

1.2. Related Works

Some excellent projects provide insights and required assistances regarding MANET in order to build our current project.

In Dr. R. Shanmugavadivu and B. Chitra2's study "A COMPARISON OF REACTIVE ROUTING PROTOCOLS DSR, AODV AND TORA IN MANET", three reactive routing protocols DSR, AODV and TORA were compared and the advantages and disadvantages of them were analyzed as well [6].

In N. Adam's study "Effect of node density on performances of three MANET routing protocols - IEEE Conference Publication", the author analyzed the performance using the following metrics: packet delivery ratio, end-to-end delay, packet dropped, routing load and end-to-end throughput [1].

And in previous year's project "Simulating MWSN with Varying Parameters" which was written by Younghoon Jee, Sam Swerhone and Liam O'Shaughnessy. They analyzed and compared AODV, DSDV, DSR and OLSR protocols based on NS-3 technology [12].

Chapter 2.

Literature Review

2.1. Reactive Routing Protocol

Reactive routing protocol is a kind of communication protocol [11]. The main purpose is to react based on the demand. Unlike proactive routing protocols maintain routes to all destinations, reactive routing protocol can significantly reduce routing overhead because they do not need to search for and maintain the route on which there is no data traffic [10]. A mobile ad hoc network (MANET) contains several different reactive protocols such as dynamic source routing (DSR), ad hoc distance vector routing algorithm (AODV) and temporally ordered routing algorithm (TORA) [11].

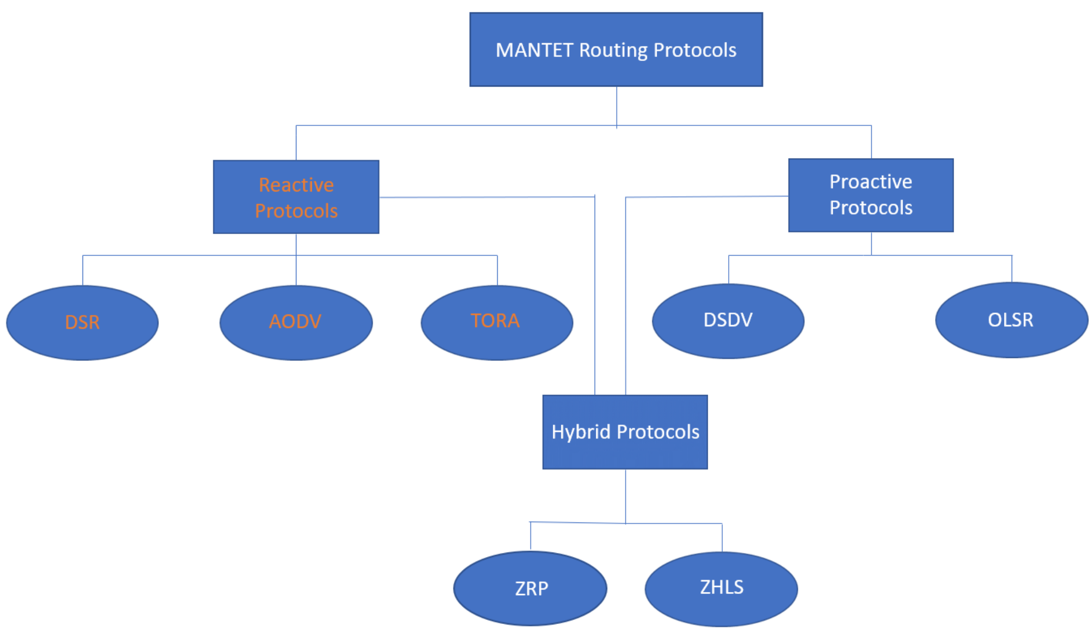

Figure 1: MANET protocols hierarchy

2.2. Dynamic Source Routing (DSR)

Dynamic source routing (DSR) is a routing protocol for wireless mesh network [7] and it is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes [11].

For some proactive protocols, to accomplish source routing, the routed packets contain the address of each device the packet will traverse, which may result in high overhead for long paths or large addresses, however, as a kind of on-demand protocol, DSR can restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach [7]. And what is different from other on-demand routing protocols, DSR is beacon-less and hence does not require periodic help packet transmissions because DSR use a node to inform its neighbors of its presence [6].

The table 1 shows the advantages and disadvantages of DSR as below:

Table 1: Advantages and Disadvantages of DSR

Advantages	**Disadvantages**
Eliminates the need to periodically flood the network with table update messages	The route maintenance mechanism does not locally repair a broken link
Eliminates the need to find routes to all other nodes in the network	Might result in inconsistencies during the route reconstruction
Reduces the control overhead by utilizing the route cache information	The performance degrades rapidly with increasing mobility

2.3. Ad hoc On-Demand Distance Vector (AODV) Routing

Since DSR includes the entire route information in the data packet header, when the data contents in a packet are small, it may waste bandwidth and degrade performance [10]. AODV routing can resolve this to some extent by keeping the routing information in each node. AODV uses forwarding tables at each node so that the route is calculated hop by hop, so compared to DSR, the data packet need not include the total path.

In AODV, when a node receives an RREQ packet, it will establish a reverse path which points to the source [10]. And when there is a route to the destination, the destination will send a route reply packet to the source node using the reverse path established when the RREQ was forwarded as responds [10]. After the source receiving the RREP, the path is established.

The table 2 shows the advantages and disadvantages of AODV as below:

Table 2: Advantages and Disadvantages of AODV

Advantages	Disadvantages
Can respond very quickly to the topological changes that affect the active routers	Has a high processing demand
Support both unicast and multicast packet transmission	Consumes a large share of the bandwidth
Lower setup delay for connections and detection of the latest route to the destination	Take a long time to build the routing table

2.4. Temporally Ordered Routing Algorithm (TORA)

TORA is a distributed routing protocol based on a “link reversal” algorithm and is designed to discover routes on demand [6]. Different from DSR and AODV, in TORA, the nodes maintain routing information about adjacent nodes so that the control message are localized to a small set of nodes [6].

In TORA, each node has a height associated with it and links between nodes flow from in with a higher to one with a lower height. The path will be established ultimately between the DAG formed by the nodes and all the nodes [6].

The table 3 shows the advantages and disadvantages of TORA as below:

Table 3: Advantages and Disadvantages of TORA

Advantages	Disadvantages
Create a DAG only when necessary	Periodic beaconing leads to unnecessary bandwidth consumption
Multiple paths created	Not scalable by any means
Good in dense networks	High processing demand

Chapter 3.

Scenarios Setup and Result Analysis

The simulation scenarios are designed in warehouses of different sizes. In these warehouses there are some wireless LAN workstations acting as robots generating, sending and receiving network traffic such as FTP. There is a wireless LAN server which runs different MANET routing protocols and routes data packets between clients and server at different transmission rates. Moreover, the varying total number of workstations and source transmission rate are interested parameters to analyse. In order to evaluate these three routing protocols, we choose end-to-end throughput as the performance metric.

The table 4 shows the general simulation parameters as below:

Table 4: General Simulation Parameters

Simulation time	1 Hour
Bandwidth	2 Mb
Traffic type	FTP
Packet size	512
Number of nodes	10, 25 and 50 nodes
Transmission power	0.005 W, 0.03 W, and 0.05 W
Source data rate	1 Mbps, 2 Mbps and 5.5 Mbps
Environment size	10×10, 10×15 and 10×20

Riverbed Modeler 17.5 academic edition is used to implement the four simulation scenarios which are in the list below:

1. Performance based on varying number of nodes
2. Performance based on varying transmission power
3. Performance based on the varying source data rate
4. Performance based on the varying environment size

3.1. Performance based on varying number of nodes

The figure 2 shows a 50-node AODV network. All nodes in the network are configured to run AODV protocols and multiple FTP sessions. The number of nodes varies from 10, 25 to 50.

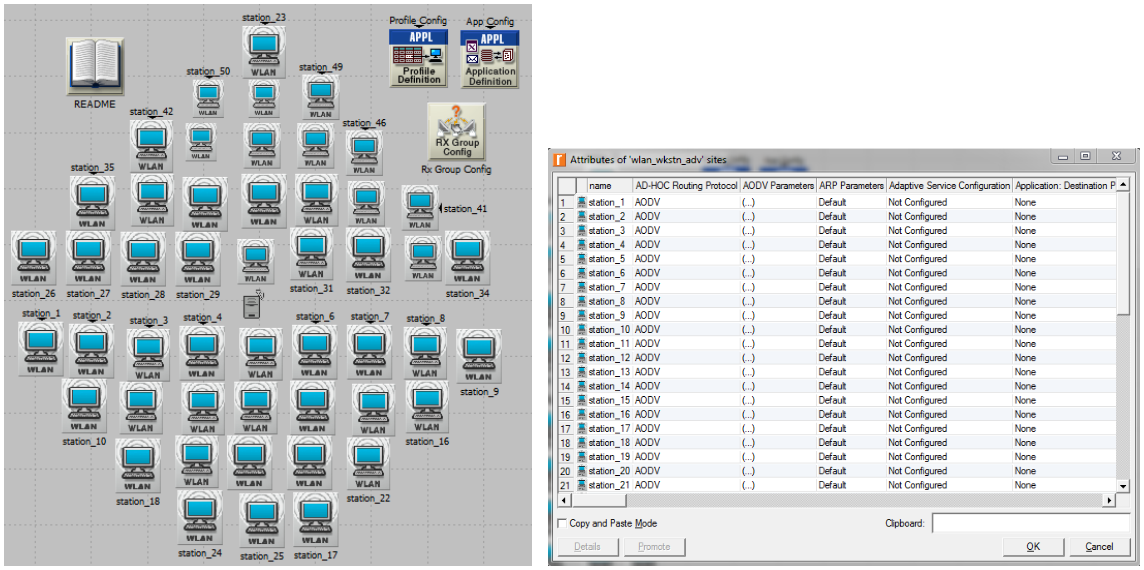

Figure 2: 50-node AODV network

After running the simulation for 1 hour. The figure 3, figure 4 and figure 5 show the simulation result of AODV, DSR and TORA network throughput with 10, 25 and 50 workstations respectively.

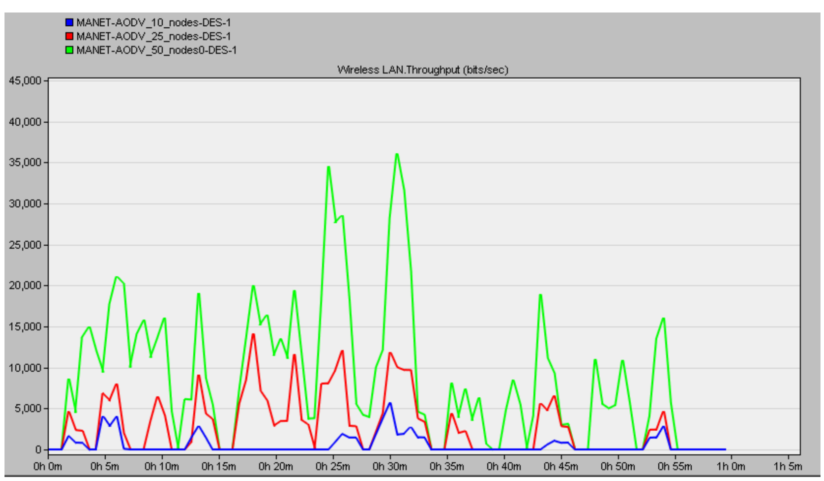

Figure 3: AODV network throughput with varying number of nodes

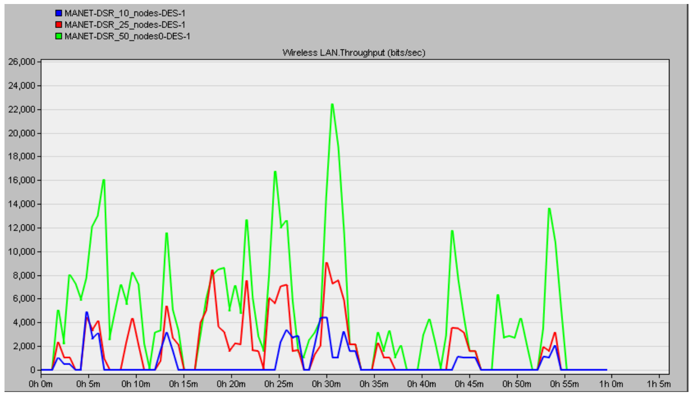

Figure 4: DSR network throughput with varying number of nodes

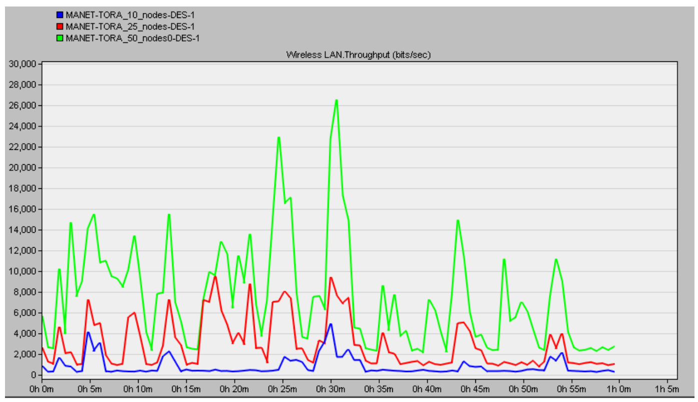

Figure 5: TORA network throughput with varying number of nodes

Results: As the figure 6 shows below, the network throughput is increasing as the number of nodes increases for all three routing protocols. Among these protocols, AODV has the largest throughput for any number of nodes situations. And both DSR and TORA performs quite similar increase trend in this scenario.

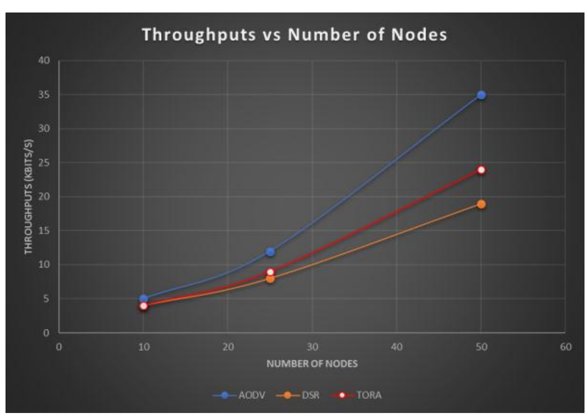

Figure 6: Throughput vs Number of nodes

3.2. Performance based on varying transmission power

The figure 7 shows a 50-node DSR network. All nodes in the network are configured to run DSR protocols and multiple FTP sessions. The transmission powers are set as 0.005 W, 0.03 W and 0.05 W respectively.

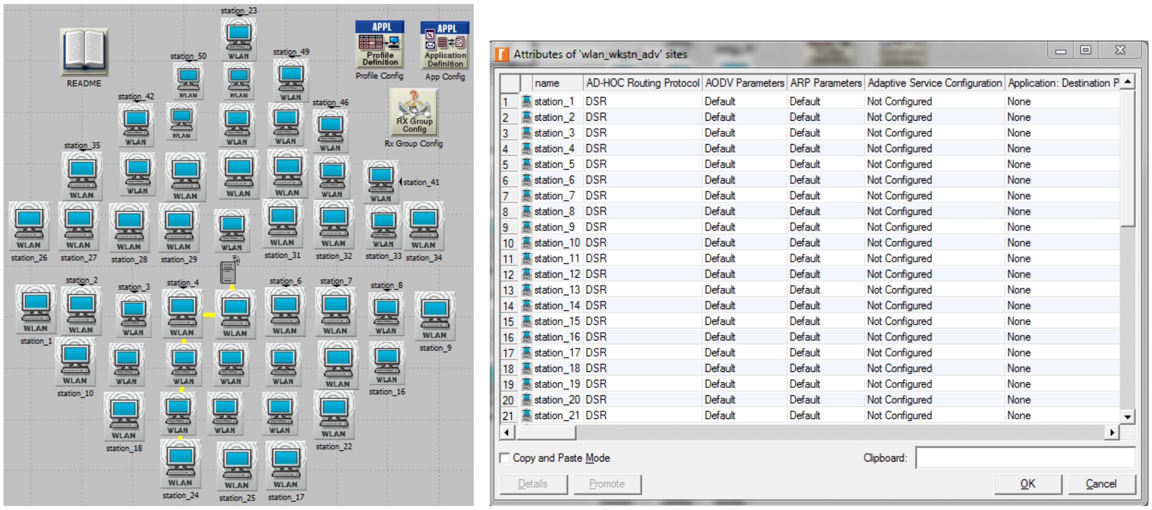

Figure 7: 50-node DSR network with 0.005 W

After running the simulation for 1 hour. The figure 8, figure 9 and figure 10 show the simulation result of AODV, DSR and TORA network throughput with transmission power of 0.005 W, 0.03 W and 0.05 W respectively.

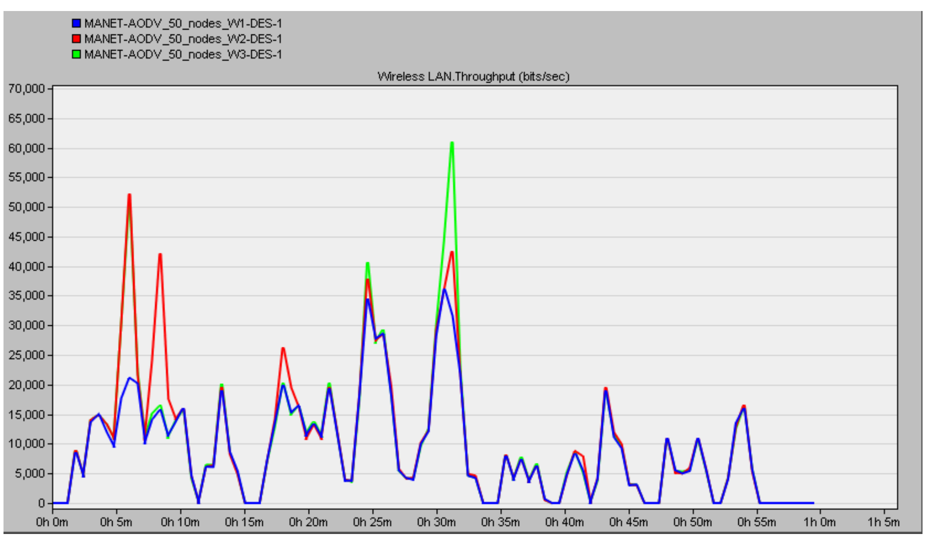

Figure 8: AODV network throughput with varying transmission power

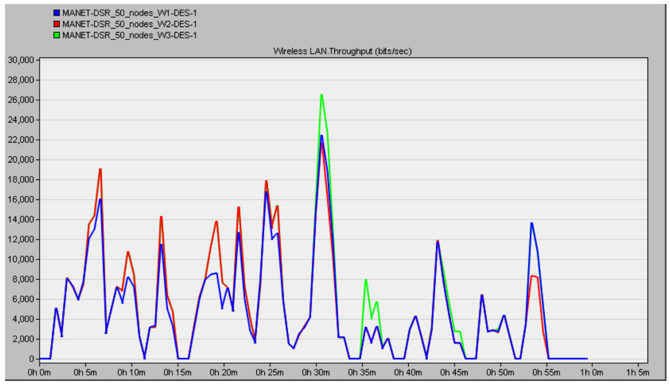

Figure 9: DSR network throughput with varying transmission power

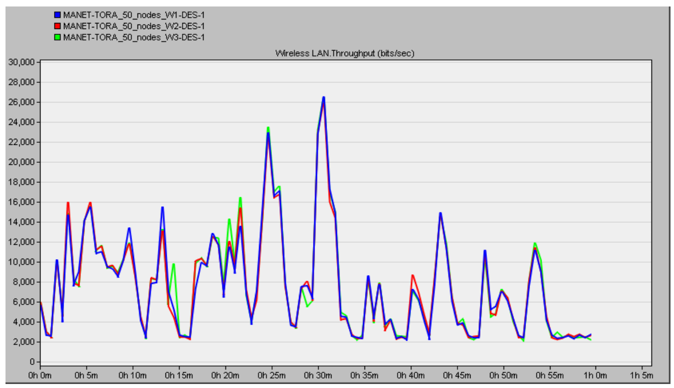

Figure 10: TORA network throughput with varying transmission power

Results: From the figure 11 shows below, the network throughput is slightly increasing as the transmission power increases for all three routing protocols. Among these three protocols, AODV performs the largest rise in throughput with the increase of transmission power. However, both DSR and TORA don't show significant growth.

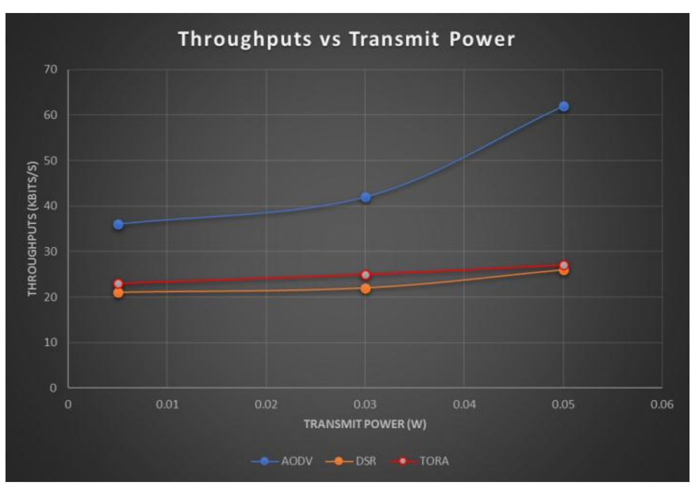

Figure 11: Throughput vs Transmission power

3.3. Performance based on varying source data rate

The figure 12 shows a 50-node TORA network. All nodes in the network are configured to run TORA protocols and multiple FTP sessions. The source data rates are configured as 1 Mbps, 2 Mbps and 5.5 Mbps respectively.

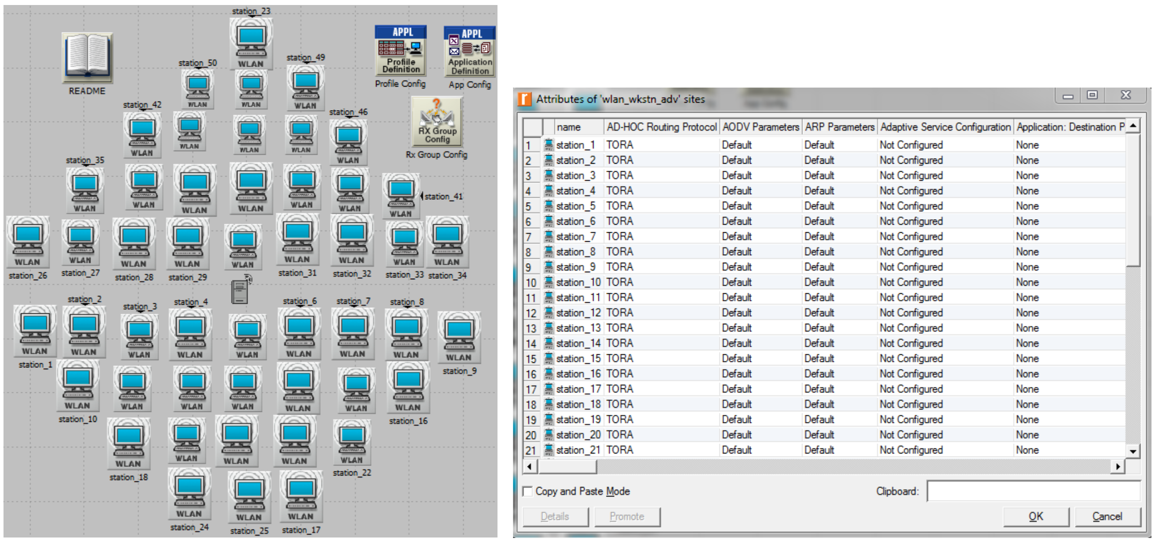

Figure 12: 50-node TORA network with 1 Mbps

After running the simulation for 1 hour. The figure 13, figure 14 and figure 15 show the simulation result of AODV, DSR and TORA network throughput with source data rates of 1 Mbps, 2 Mbps and 5.5 Mbps respectively.

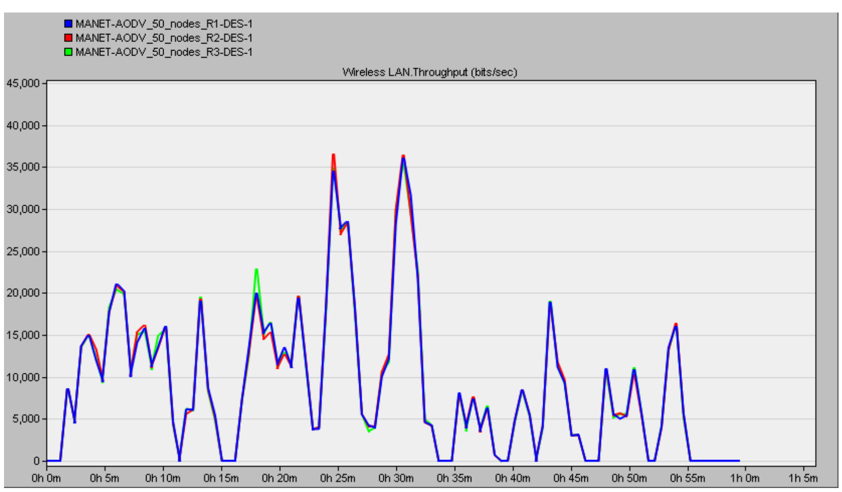

Figure 13: AODV network throughput with varying source data rate

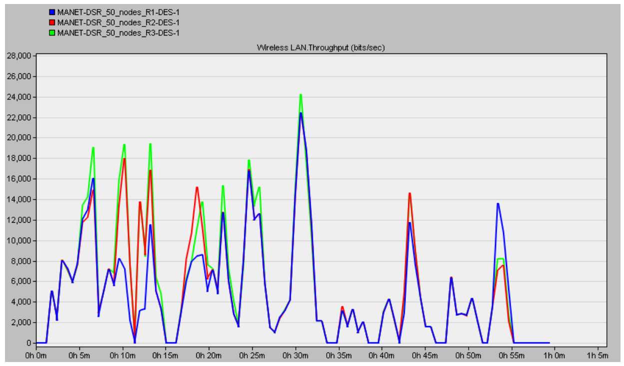

Figure 14: DSR network throughput with varying source data rate

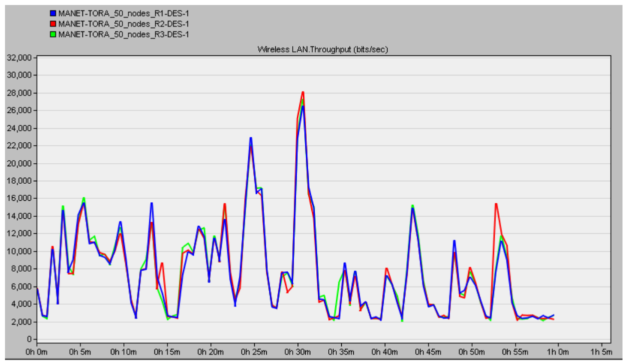

Figure 15: TORA network throughput with varying source data rate

Results: As the figure 16 shows below, an increase in the source data rate causes an increase in throughput for all three routing protocols. In addition, DSR shows the maximum growth in throughput with the increase of source data rate. However, TORA doesn't perform significant increase.

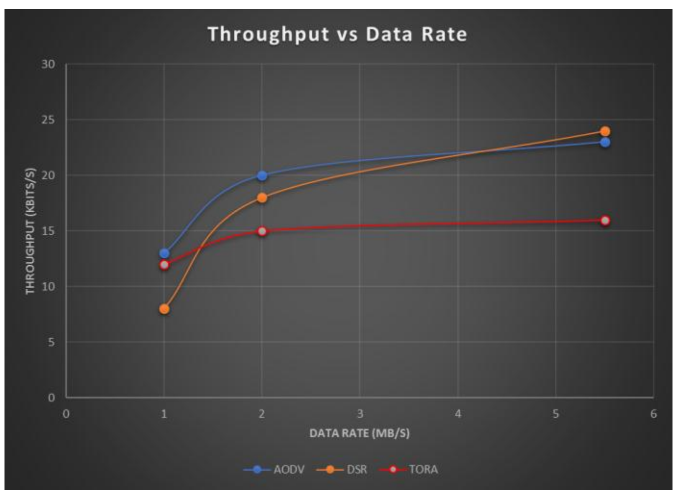

Figure 16: Throughput vs Source data rate

3.4. Performance based on varying environment size

The figure 17 shows a 50-node DSR network. All nodes in the network are configured to run DSR protocols and multiple FTP sessions. The environment sizes are set as 10×10, 10×15 and 10×20 respectively.

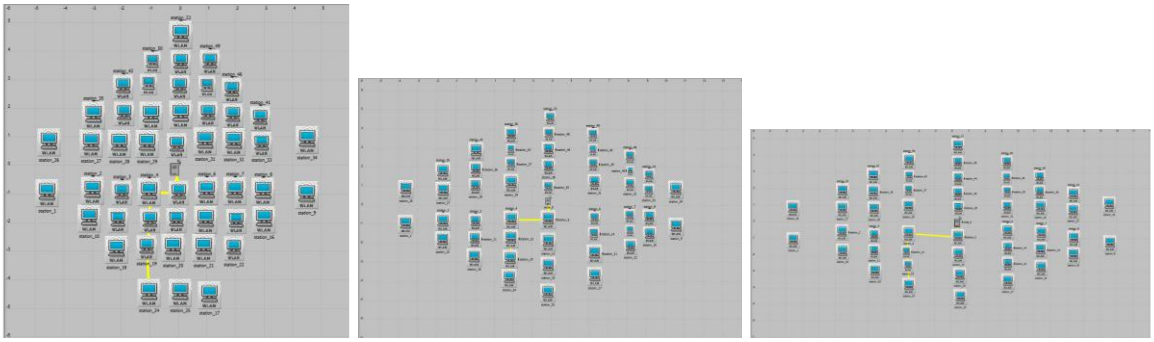

Figure 17: 50-node DSR network with different environment sizes

After running the simulation for 1 hour. The figure 18, figure 19 and figure 20 show the simulation result of AODV, DSR and TORA network throughput with environment size of 10×10, 10×15 and 10×20 respectively.

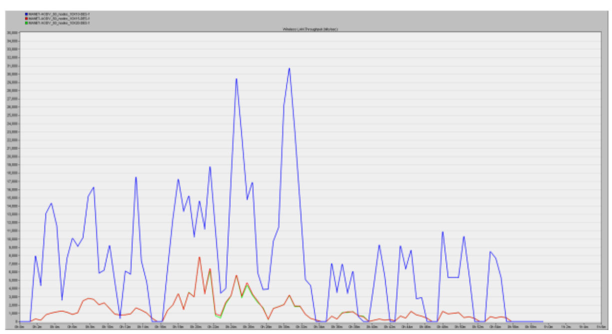

Figure 18: AODV network throughput with varying environment sizes

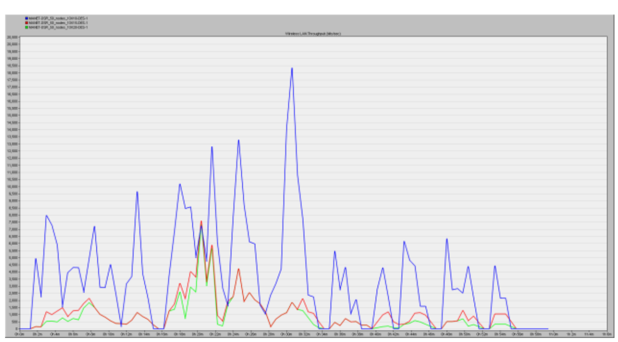

Figure 19: DSR network throughput with varying environment sizes

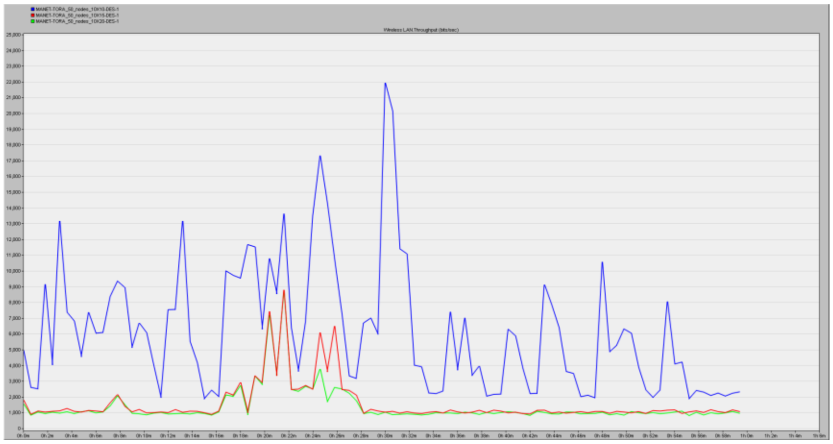

Figure 20: TORA network throughput with varying environment sizes

Results: The figure 21 obviously shows that environment size has a direct effect on the network throughput. With other parameters being held constant, increasing environment size results in a decrease in throughput. Moreover, AODV has the maximum decline in throughput with the increase of environment size. Besides, both DSR and TORA perform similar downtrend.

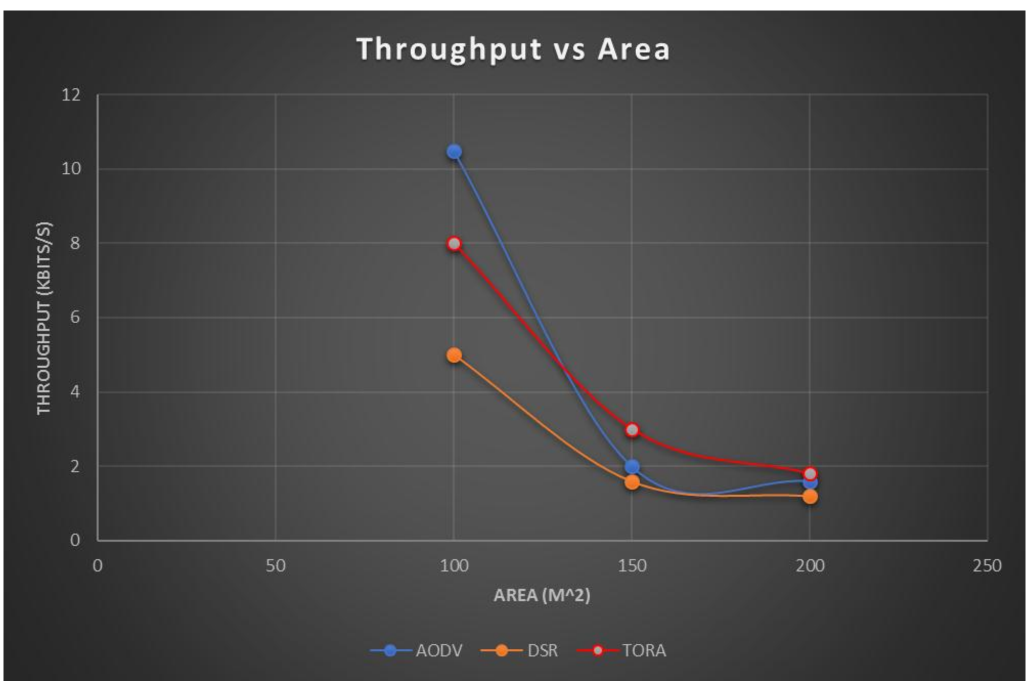

Figure 21: Throughput vs Environment sizes

Chapter 4.

Conclusion

4.1. Accomplishment

In this project, all protocols have been simulated using the same general parameters for each scenario to ensure accurate results. For each scenario, the evaluation of the performances for three MANET routing protocols are fulfilled using riverbed modeler 17.5 academic edition. Table 5 summarises the performances comparison of the three protocols. In general, AODV, DSR and TORA perform quite similar in the four scenarios. From the observation, we can see that AODV performances best through all scenarios. In addition, DSR performs better than TORA in the source data rate scenario.

Table 5: Performances Comparison of Three Routing Protocols

Scenarios	Protocols		
	AODV	DSR	TORA
Number of nodes	1	3	2
Transmission power	1	3	2
Data rate	1	2	3
Environmental size	1	3	2

4.2. Future Work

In the future, we would like to learn more about these routing protocols by adding more dynamic scenarios such as varying the source data rate with time and varying the speed of mobile nodes. And we also want to further investigation in adding more performance metrics such as packet delivery ratio and end-to-end delay to compare the performance of these protocols. Moreover, we would like to gain more insight into MWSN networks by optimizing one of the three protocols like AODV by controlling the broadcasting of RREQ information and evaluate the improvement.

References

1. N. Adam, "Effect of node density on performances of three MANET routing protocols - IEEE Conference Publication", Ieeexplore.ieee.org, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/5503051/. [Accessed: 06- Feb- 2020]

2. Y. Fan, "OPNET-based Network of MANET Routing Protocols DSR Computer Simulation - IEEE Conference Publication", Ieeexplore.ieee.org, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/5571674/. [Accessed: 06- Feb- 2020]

3. M. Fazeli and H. Vaziri, "Assessment of Throughput Performance Under OPNET Modeler Simulation Tools in Mobile Ad Hoc Networks (MANETs) - IEEE Conference Publication", Ieeexplore.ieee.org, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/6005694/. [Accessed: 06- Feb- 2020]

4. H. Singh, "Performance Investigation of Reactive AODV and Hybrid GRP Routing Protocols under Influence of IEEE 802.11n MANET- IEEE Conference Publication", Ieeexplore.ieee.org, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/7079101/. [Accessed: 06- Feb- 2020]

5. M. Rajput, "Comparison of Ad-hoc reactive routing protocols using OPNET modeler- IEEE Conference Publication", Ieeexplore.ieee.org, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/5643454/. [Accessed: 06- Feb- 2020]

6. Dr. R. Shanmugavadivu and B. Chitra, "A COMPARISON OF REACTIVE ROUTING PROTOCOLS DSR, AODV AND TORA IN MANET," 2016. [online] Ijarcet.org. Available at: <http://ijarcet.org/wp-content/uploads/IJARCET-VOL-5-ISSUE-2-296-300.pdf> [Accessed 7 April 2020].

7. En.wikipedia.org. 2020. *DSR*. [online] Available at: <https://en.wikipedia.org/wiki/DSR> [Accessed 7 April 2020].M. Rajput, "Comparison of Ad-hoc reactive routing protocols using OPNET modeler- IEEE Conference Publication", Ieeexplore.ieee.org, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/5643454/. [Accessed: 06- Feb- 2020]

8. En.wikipedia.org. 2020. *Ad Hoc On-Demand Distance Vector Routing*. [online] Available at: <https://en.wikipedia.org/wiki/Ad_hoc_On-Demand_Distance_Vector_Routing> [Accessed 7 April 2020].M. Rajput, "Comparison of Ad-hoc reactive routing protocols using OPNET modeler- IEEE Conference Publication", Ieeexplore.ieee.org, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/5643454/. [Accessed: 06- Feb- 2020]

9. En.wikipedia.org. 2020. *Temporally Ordered Routing Algorithm*. [online] Available at: <https://en.wikipedia.org/wiki/Temporally_ordered_routing_algorithm> [Accessed 7 April 2020].

10. Webhome.csc.uvic.ca. 2020. [online] Available at: <http://webhome.csc.uvic.ca/~wkui/Courses/wireless/Lecture4.pdf> [Accessed 7 April 2020].

11. S. Kalwar, "Introduction to reactive protocol," in IEEE Potentials, vol. 29, no. 2, pp. 34-35, March-April 2010.

12. Jee, Y., Swerhone, S. and O’Shaughnessy, L., 2019. [online] Sfu.ca. Available at: <http://www.sfu.ca/~ljilja/ENSC427/Spring19/Projects/team10/ENSC427_team10_report.pdf> [Accessed 7 April 2020].